ELECTRIC
EMF
WELDING

# Arc Welding Electrodes

BETTER
WELDING

**E.M.F. Electric Co.**
PTY. LTD.
1005 Rathdown St., North Carlton
VICTORIA
Telephones: FW 4112 (4 lines)    Telegrams: "Elecweld," Melbourne

Manufacturers of Plant and Accessories for Arc and Resistance Welding and Resistance Heating.

# E.M.F. ARC WELDING ELECTRODES

## CONTENTS

SECTION I.

For Welding Mild Steel Page
General Work 4
Sheet Steel 16
Heavy Gauge Electrodes 18

SECTION II.

For Welding Cast Iron 21

SECTION III.

For Welding Carbon and Alloy Steels and for Hard Surfacing 26

SECTION IV.

For Welding Stainless and Heat Resisting Austenitic Steels 34

SECTION V.

For Welding Monel Metal 37

SECTION VI.

For Cutting 38

LIST OF E.M.F. ELECTRODES 40, 41

DESIGN DATA

New Era Electrodes 42, 43

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# E.M.F. ELECTRODES

THE recommendations herein embody the results of many years of research and experiment and also the experiences of our many users in shop and field. They are presented for the guidance of all those engaged in the art of Electric Welding.

### *Welding Plants.*

All E.M.F. Electrodes are suitable for either A.C. or D.C. plants, but in order to obtain the best and sometimes the cheapest results the following points should be noted:—

A.C. plants should have an open circuit voltage of between 70 and 90 volts. The welding voltage should be higher for the heavily fluxed electrodes than for bare wire welding. For heavily fluxed electrodes of less than 12 gauge, Arc Rods of less than 10 gauge, and some alloy steel electrodes, a " Pilot Arc " Attachment should be used with A.C. plants to facilitate the striking and maintenance of the arc.

When using D.C. the polarity of the electrode may be either positive or negative, depending on the conditions of the work in hand. In general, positive polarity is the more suitable for the electrode, the polarity of the work being negative. This arrangement is frequently termed " reverse polarity." However, in the case of Arc Rods and certain special alloy steel electrodes, the opposite method of connection is preferable, so that it may often be desirable to try both polarities when commencing to weld.

## SECTION I.

# ELECTRODES FOR WELDING MILD STEEL.

The main uses, characteristics and properties of the weld metal obtainable from the various types of electrodes are summarised for convenience in order of quality, as follows:—

| Electrode. | Uses and Special Characteristics. | Physical Properties of Deposited Weld Metal. | | |
|---|---|---|---|---|
| | | Ten. Str. Tons per sq. in. | Elongation 8 Diam. | Izod ft. lbs. |
| New Era (Extra Fluxed) | For important welding on mild steel in structural work, machinery, etc. Recommended for welds carrying high stresses or subject to impact or fatigue loading. It is suitable for boiler work and can be forged. Under good conditions will produce smooth neat welds. The electrode complies with the S.A.A. Code requirements for Structural Grade Electrodes and Lloyd's specification for electrodes for welding of primary structural importance. | 29-33<br>These properties are improved by hot working. | 20-25% | over 40 |
| New Era (Vertical) | Exceptionally suitable for welding vertically down. The electrode complies with the S.A.A. Code requirements for Structural Grade Electrodes and Lloyd's specification for electrodes for welding of primary structural importance. | do. | do. | do. |
| General Purpose | Suitable for welding mild steel in all positions. The electrode complies with the S.A.A. Code requirements for Structural Grade Electrodes. | 29-33 | 18-22% | 35 |
| Weld Rod (346C) | For general welding of mild steel. A good mild steel electrode having easy running characteristics giving exceptionally smooth finished welds, but having physical characteristics slightly below those of New Era. | 29-33 | 18-22% | 35 |
| Mild Steel | A general purpose electrode for welding mild steel and wrought iron. Suitable for overhead and vertical welding. | 24-28 | 9-15% | 25 |
| Arc Rod | For work where low cost is necessary and first-class quality not essential. | 24-28 | 7-10% | 12 |

### *Copper Bearing Electrodes.*

The electrodes set out in the foregoing table, with the exception of Arc Rods, can be supplied to deposit a weld metal containing copper in various percentages as required. For further information see page 16.

### *Welding Procedure.*

The physical properties of welds made with the various electrodes are dependent to a large extent on the employment of proper welding procedure.

It is important to use—

1. A gauge of electrode suitable for the thickness of plate or section to be welded.
2. A suitable size of run for the gauge of electrode.
3. Welding current within the limits given on the package labels.

The respective recommendations concerning the different types of electrodes are set out in the sub-section relating to each type. The information has been amplified in the design data table shown on pages 42 and 43, but the strengths per lineal inch of weld shown in the latter table do not of necessity apply to other than New Era Electrodes.

Runs per electrode for any given thickness of plate and gauge of electrode must be neither too long nor too short. The energy input per lineal inch of weld must remain within fairly well defined limits, or the quality of the weld will suffer to a marked extent.

Since there are limits to the current carrying capacity of any electrode, the use of too long a run, involving rapid traverse of the electrode, may easily cause the energy input per lineal inch to fall below safe limits. The marked shortening of the time and temperature of chemical reaction also tends towards incomplete flux action and somewhat inferior weld metal. There is almost always oxide of iron or scale on the parts to be welded, and just sufficient time for a complete fluxing of the scale is the most desirable condition.

Adherence to correct procedure will ensure the best metallurgical conditions for the weld metal, as it results in fairly rapid cooling and ensures that the weld metal does not remain above red heat for more than a few seconds after the weld is completed, this being necessary in order to obtain high ductility and shock strength. Where exceptional circumstances, such as difficulty in obtaining proper preparation, necessitates a departure from normal procedure, a reduction in the toughness of the weld metal may be expected.

Correct procedure will also ensure a minimum of distortion, ease of supervision and maximum economy.

### *Selection of Electrodes.*

There are several aspects to be considered when selecting the type of electrode to be used for any particular work in hand. Strength, ductility and toughness of weld metal are always required, but in varying degrees, and the approximate figures of these physical properties are enumerated in the table, set out on page 4, of mild steel electrodes. The other aspects are *cost* and *weldability*

### *Cost.*

The first cost of the electrode is seldom an indication of the ultimate cost of the welding. In average cases the proper use of the best quality electrodes, that is the New Era type, will be found to pay if consideration be given to the higher tensile strength of the welds. If in addition consideration be given to ductility and Izod shock value the advantage is still greater.

This conclusion does not invariably hold, as in some work, such as in tanks with a ¼ inch plate thickness and under, and in light structures, the design is such that over-welding cannot be avoided. For such work E.M.F.

Weld Rods or Mild Steel Electrodes are recommended. For building up where bulk of metal is the only consideration Arc Rods may be suitable, but if finish and resistance to wear and corrosion are considerations it may be desirable to use an electrode of higher quality.

### *Weldability.*

One of the special features of the E.M.F. Electrodes for welding on mild steel is versatility, nevertheless certain mild steel electrodes have characteristics which are better suited than others to meet the requirements of certain types of welding, and their special adaptability and efficiency have not been reduced by attempts to make them suitable for universal application. The E.M.F. General Purpose Electrode has been produced to meet the latter requirement.

### *Special Requirements.*

For forging or hot working, the New Era (Extra Fluxed), New Era (Vertical), and General Purpose Electrodes are recommended.

For case hardening the New Era (Extra Fluxed) and New Era (Vertical) Electrodes are suitable, but the E.M.F. Nickel Steel Electrodes are preferable.

For plug welds and high current welding New Era (Extra Fluxed) Electrodes are recommended.

## NEW ERA (EXTRA FLUXED) AND NEW ERA (VERTICAL) ELECTRODES.

Both these types of electrodes deposit weld metal having similar physical properties, but they differ in running characteristics and in the amount and character of the resulting slag.

The gauges of electrodes recommended for welding various thicknesses of plates or sections, and the lengths of run in inches per electrode, are as follows for either type:—

| Electrode Gauge. | Thickness of Plate. | Length of Run. | | |
|---|---|---|---|---|
| | | Normal. | Min. | Max. |
| 4 | 1/2" and over | 15 | 10 | 18 |
| 6 | 3/8" and over | 12 | 9 | 15 |
| 8 | 1/4" to 1/2" | 9 | 7 | 12 |
| 10 | 3/16" to 3/8" | 7 | 5 | 9 |
| 12 | 1/8" and under | 5 | 4 | 6 |

## NEW ERA (EXTRA FLUXED) ELECTRODES.

These electrodes, as signified by their name, are heavily fluxed and are designed to give a neatly finished weld. The slag, although copious, is easily controlled and can be subsequently removed from the welding with ease. When hot, it completely covers the weld metal and retards the freezing sufficiently for the molten steel to smooth itself out, resulting in a neat, even bead.

When using these electrodes, the welder must maintain a short arc. It will be found that it is often possible to touch the electrode tip on the plate, without it freezing on. If a long arc is used, the slag will become less fragile and lose its covering properties and thus the weld metal will lose its normal smooth appearance. For downhand (horizontal down) welds, no attempt should be made to throw the slag back from the crater, as the slag is very light and will always float to the surface of the weld metal.

Best results are obtained by using a *slightly higher* welding current than is usual for other types of electrodes of the same gauge, the currents recommended for the various gauges being as follows:—

|  | Amperes |  |  |
|---|---|---|---|
| Gauge. | Normal. | Minimum. | Maximum. |
| 4 | 280 | 200 | 350 |
| 6 | 190 | 140 | 230 |
| 8 | 160 | 125 | 180 |
| 10 | 120 | 90 | 135 |
| 12 | 85 | 55 | 100 |

For vertical welds, the first run should usually be made by welding upwards. Succeeding runs can then be made by welding either vertically down or up, whichever is more suitable. When welding vertically downwards, the electrode should be used pointing slightly downwards, so that the excess slag will run down in front of the arc crater.

***Special Uses.***

On account of the lightness of the slag and its ease of removal, New Era (Extra Fluxed) Electrodes are suitable for plug welds. The insulating properties of the covering prevent arcing from the sides of the electrode to the plate.

This electrode can be used with high welding currents without loss in the physical properties of the metal. As a result it is possible to make butt welds in plates not exceeding ½ inch in thickness without preparation of chamfered edges. With high currents and a carefully maintained gap, complete penetration is possible for certain thicknesses of plate. The correct gap must be maintained by efficient clamps or tack welds. The gauge of electrode, welding current and gap required for these welds are set out in the table below:—

## NEW ERA (EXTRA FLUXED) ELECTRODES.

*Butt Welds with no Preparation.*

| Thickness of Plate. | How Welded. | Alternative Gauge of electrode SWG. | Welding Current. Amperes. | Gap. | Approx. size of Run. |
|---|---|---|---|---|---|
| 3/16" | From one side with backing | 10 | 125 | 1/8" | 10/7 |
| | | 8 | 150 | | 8/10 |
| 1/4" | From one side with backing | 8 | 170 | 3/16" | 8/9 |
| | | 6 | 190 | | 6/12 |
| | | 4 | 270 | | 4/15 |
| 1/4" | From both sides | 10 | 125 | 1/8" | 2-10/9 |
| | | 8 | 150 | | 2-8/12 |
| 5/16" | From one side with backing | 6 | 210 | 3/16" | 6/9 |
| | | 4 | 290 | | 4/12 |
| 5/16" | From both sides | 8 | 170 | 1/8" | 2-8/9 |
| | | 6 | 210 | | 2-6/14 |
| | | 4 | 280 | | 4/17 |
| 3/8" | From both sides | 6 | 210 | 1/8" | 2-6/13 |
| | | 4 | 290 | | 2-4/14 |
| 1/2" | From both sides | 4 | 350 | 1/8" | 2-4/13 |

Each of these welds, if properly made, should give a tensile strength not less than 28 tons per square inch over the cross sectional area of the joint. If D.C. is used the individual characteristics of the generator may necessitate slight changes in the current values given in the table, which should be used as a guide only. Before carrying out any work a test weld should be made and sawn through to determine whether the right conditions for full penetration are being obtained.

The foregoing information relates principally to 6, 8, 10 and 12 gauges. New Era (Extra Fluxed) 3/8" and 5/16" dia. and 4 gauge electrodes for large fillets can also be supplied. The characteristics of these electrodes are, in general, similar to those of the medium gauges, but particulars of their special applications will be found on Pages 18 to 20 under the heading " Heavy Gauge Electrodes."

## NEW ERA (VERTICAL) ELECTRODES.

The New Era (Vertical) Electrode, while fully fluxed, is not as heavily fluxed as the New Era (Extra Fluxed) Electrode.

The electrode can be used in all positions, but is particularly suitable for welding vertically down. For all other electrodes welding upwards is recommended for the first run of a vertical weld, either in a fillet or a butt weld, on account of the danger of lack of fusion in the corner and a consequent reduced throat thickness. With the New Era (Vertical) Electrode this does not apply, as the amount of slag is small and readily falls away, and the corner of a fillet or the bottom of a vee is left clean.

In multiple run vertical welds, any slag on a preceding run, although apparently very small in amount, should be chipped and brushed away before depositing the next run. If this is not done, the weld metal of the subsequent runs will tend to fall away.

When welding on the flat or in the downhand (horizontal down) position, the slag should be allowed to run ahead of the crater, instead of being thrown back over the bead, as is usual with most other electrodes. If this is not done, the slag will inlay and spoil the appearance of the bead. The manipulation of the slag is assisted if the work can be given a slight downward tilt in the direction of the welding.

To avoid undercut, the weld should be made with a limited amount of weaving. Only sufficient lateral movement should be made to ensure complete fusion at the sides of the weld, while the traverse of the electrode along the line of the welding should be sufficiently slow to allow the molten metal to flow to the sides of the weld and build up the bead to the required height. In the unpracticed hand, the New Era (Vertical) Electrode may appear to be slightly difficult to use, but with a little practice the welder should have no difficulty in producing excellent welds.

The property of deep penetration makes this electrode particularly suitable for use on wrought iron, where the strength of the weld depends upon the ability of the weld metal to pull out laminations of the plate.

New Era weld metal will case-harden satisfactorily with any of the usual case-hardening compounds.

New Era (Vertical) Electrodes are made in 6, 8, 10 and 12 gauges. For vertical work requiring lighter gauges, either E.M.F. Sheet Steel or General Purpose Electrodes are recommended, and New Era (Extra Fluxed) Electrodes for general work requiring electrodes heavier than 6 gauge.

The recommended welding currents are as follows:—

| | Amperes | | |
|---|---|---|---|
| Gauge. | Normal. | Minimum. | Maximum. |
| 6 | 180 | 155 | 210 |
| 8 | 145 | 125 | 165 |
| 10 | 125 | 110 | 140 |
| 12 | 85 | 75 | 95 |

## GENERAL PURPOSE ELECTRODES.

E.M.F. General Purpose Electrodes are suitable for welding mild steel in all positions. The electrode complies with the S.A.A. Code requirements for Structural Grade Electrodes, and is therefore suitable for important work where strength is a primary consideration.

The field of application for these electrodes is wide, as the nature of the flux and the small amount of slag produced permit of easy manipulation of the electrode in every position. The electrodes are specially suitable for welds in awkward corners or other difficult places. They can also be used with much less current than is normal for electric welding, and this feature makes it possible to deposit lighter beads on thinner material than is usual for other electrodes of the same gauge.

Welding procedure recommendations are as follows:—

| Electrode Gauge | Thickness of Plate. | Length of Run in Inches per Electrode. | | | Welding Current (Amperes). | | |
|---|---|---|---|---|---|---|---|
| | | Normal. | Min. | Max. | Normal. | Min. | Max. |
| 4 | 3/8" and over | 15 | 10 | 22 | 250 | 140 | 330 |
| 6 | 1/4" and over | 12 | 9 | 19 | 180 | 95 | 265 |
| 8 | 1/8" and over | 9 | 7 | 16 | 145 | 85 | 190 |
| 10 | 1/16" to 3/8" | 7 | 5 | 10 | 110 | 65 | 125 |
| 12 | 1/8" and under | 5 | 4 | 9 | 70 | 35 | 80 |

## WELD ROD ELECTRODES.

E.M.F. Weld Rods are suitable for the welding of tanks and other structural work in mild steel where the better physical properties of the weld metal deposited by New Era Electrodes are not essential. In running characteristics, they are somewhat similar to the New Era (Extra Fluxed) Electrodes, and the notes concerning the manipulation of those electrodes also apply to Weld Rods. The electrodes are most suitable for welding in the downhand (horizontal down) or overhead positions.

The welds have an exceptionally neat, even contour, a factor which makes it unnecessary to dress up or fill welds which are to be painted.

The electrode is particularly suitable for resurfacing or building up work, the weld metal being soft, machinable, and sound and free from defects. It should not, however, be used where case-hardening is to be carried out.

The electrode is not recommended for work where subsequent hot working is required, for which New Era

Electrodes should be used. For vertical welds, New Era (Vertical) Electrodes will give better results. Weld Rods are made in the following gauges:—4, 6, 8, 10 and 12.

Welding procedure recommendations are as follows:—

| Electrode Gauge. | Thickness of Plate. | Length of Run in Inches per Electrode. | | | Welding Current (Amperes). | | |
|---|---|---|---|---|---|---|---|
| | | Normal. | Min. | Max. | Normal. | Min. | Max. |
| 4 | 1/2" and over | 15 | 10 | 18 | 260 | 220 | 310 |
| 6 | 3/8" and over | 12 | 9 | 15 | 190 | 135 | 240 |
| 8 | 1/4" to 1/2" | 9 | 7 | 12 | 160 | 105 | 190 |
| 10 | 3/16" to 3/8" | 7 | 5 | 9 | 120 | 75 | 135 |
| 12 | 1/8" and under | 5 | 4 | 6 | 80 | 55 | 105 |

## MILD STEEL ELECTRODES.

E.M.F. Mild Steel Electrodes are suitable for general welding in those cases where the better physical properties obtainable with New Era Electrodes are not essential. The field of their application includes structural, tank and general repair work. They are satisfactory for use on old material where foreign matter such as dirt, rust, etc., cannot be completely removed; however, reasonable cleanliness should be observed. The electrodes can be operated in any position.

They should not be used for work where subsequent hot working or case-hardening is required, for in both of these cases New Era Electrodes are recommended.

Owing to the nature of their construction with binding wires, E.M.F. Mild Steel Electrodes deposit 10% to 30% more metal than other electrodes of the same nominal gauge size.

Welding procedure recommendations are as follows:—

| Electrode Gauge. | Thickness of Plate. | Length of Run in Inches per Electrode. | | | Welding Current (Amperes). | | |
|---|---|---|---|---|---|---|---|
| | | Normal. | Min. | Max. | Normal. | Min. | Max. |
| 4 | 1/2" and over | — | — | — | 200 | 170 | 230 |
| 6 | 3/8" and over | 12 | 9 | 16 | 180 | 150 | 205 |
| 8 | 1/4" to 1/2" | 10 | 7 | 12 | 145 | 120 | 170 |
| 10 | 3/16" to 3/8" | 9 | 6 | 11 | 125 | 105 | 145 |
| 12 | 1/8" and under | 7 | 4 | 9 | 80 | 65 | 95 |

## ARC ROD ELECTRODES.

E.M.F. Arc Rods are lightly fluxed electrodes and are intended for use where the nature of the work does not demand the high physical properties obtainable with more heavily fluxed electrodes and where low cost is a matter of special importance.

Although primarily intended for use with A.C. plants, to serve the same purpose as bare wire electrodes used with D.C. machines, the appearance, the ease of running, and greater percentage deposit with Arc Rods when used with direct current render them competitive in cost with bare wire welding. There is also the advantage of better quality weld metal.

The electrodes are suitable for building-up work, but the weld metal is not suitable for hot working or case-hardening.

The recommended welding currents are as follows:—

| Gauge. | Amperes Normal. | Minimum. | Maximum. |
|---|---|---|---|
| 4 | 190 | 145 | 230 |
| 6 | 160 | 130 | 200 |
| 8 | 130 | 105 | 155 |
| 10 | 100 | 75 | 115 |

Smaller gauges of Arc Rods can also be supplied, but these are not suitable for use on A.C. without a "Pilot Arc" Attachment.

## COPPER BEARING ELECTRODES.

All of the foregoing electrodes, with the exception of Arc Rods, can be supplied to deposit weld metal containing 0.3% of Copper, and have been developed for the arc welding of copper-bearing mild steel which is used on account of its resistance to corrosion by salt water. They can be supplied in 6, 8, 10 and 12 gauges.

Electrodes to deposit weld metal containing other specified percentages of copper can also be supplied, but as these electrodes must be specially made, extra time should be allowed for the despatch of any that may be ordered.

## ELECTRODES FOR WELDING SHEET STEEL.

E.M.F. Sheet Steel Electrodes, which are available in 14, 16 and 18 gauges, and E.M.F. General Purpose Electrodes, which are available in 14 and 16 gauges, are suitable for sheet steel welding, and may be used with either A.C. or D.C. plant. General Purpose Electrodes are particularly suitable for inside corner welds. Where 12 gauge electrodes are required New Era (Extra Fluxed), Weld Rod (346c), or General Purpose Electrodes may be used.

### *Plant Required.*

For these lighter gauges the characteristics of the welding machines are an important factor in obtaining successful results. Fine adjustment of the current to within a few amperes is essential. With an A.C. machine a "Pilot Arc" Attachment is also essential, without which it is impracticable to hold an arc with the low welding current necessary for work on light sheet.

Generally, the approximate minimum thicknesses that can be welded with E.M.F. A.C. Arc Welders are as follows:—

| | |
|---|---|
| With Standard 7.5 kVA. Arc Welders .... | 14 gauge |
| With Standard Arc Welders with E.M.F. "Pilot Arc" Attachment .... .... .... .... | 16 gauge |
| With Standard Arc Welders with E.M.F. "Pilot Arc" Attachment and Sheet Metal Controller .... .... .... .... .... .... .... | 22 gauge |
| With E.M.F. "Pilot Arc" Sheet Metal Welder .... .... .... .... .... .... .... .... .... .... .... | 22 gauge |

### *Preparation.*

Good fitting of the joint is essential. If gaps are present it is difficult to bridge over with weld metal owing to the tendency to burn away the edges of the sheet, thus causing holes. In order to assist routine production, it may be advisable to provide properly designed jigs to clamp the plate securely, thus minimising the possibility of movement and buckling of the plate through the welding operation. A further aid is the inclusion in the jig of a copper backing strip along the weld, this enabling finer gauges to be welded. Frequent tack welds are also advisable, and are essential where no jigs are provided.

### *Welding Position.*

In some cases it may be found advantageous to weld in an inclined or vertical position instead of the usual welding position giving "flat" or "downhand" welding.

### *Gauge of Electrode.*

The correct gauge of electrode is also an important factor and no hard and fast rule can be laid down, as there are many varying conditions such as type of plant, type of joint, welding position, provision or otherwise of backing strips and jigs, etc.

The following recommendations are approximate for downhand welding with Sheet Steel Electrodes:—

| Gauge of Electrode | Current Amperes | Minimum gauge thicknesses of plates. | | | | |
|---|---|---|---|---|---|---|
| | | Close Butt Joint | Lap Joint | Turned Edges | Inside Corner | Outside Corner |
| 12 | 65-85 | 12 | 12 | — | 12 | 12 |
| 14 | 35-55 | 14 | 14 | 18 | 14 | 14 |
| 16 | 20-45 | 16 | 18 | 20 | 16 | 16 |
| 18 | 15-25 | 22 | 22 | 22 | 20 | 22 |

The corresponding recommendations for General Purpose Electrodes are as follows:—

| Gauge of Electrode. | Current Amperes. | Minimum gauge thicknesses of plates. | | | | |
|---|---|---|---|---|---|---|
| | | Close Butt Joint | Lap Joint | Turned Edges | Inside Corner | Outside Corner |
| 12 | 35-80 | 20 | 20 | 18 | 16 | 18 |
| 14 | 25-65 | 22 | 20 | 18 | 18 | 20 |
| 16 | 10-50 | 22 | 20 | 22 | 18 | 22 |

For best results with General Purpose Electrodes when used on thin plate, the electrode should be held perpendicularly to the work.

## HEAVY GAUGE ELECTRODES.

For heavy fillet and butt welds, E.M.F. New Era (Extra Fluxed) Electrodes of 3/8" and 5/16" diameter, and 4 gauge, are recommended subject to the use of the correct welding procedure. General Purpose Electrodes are also available in these sizes, and are recommended for building up work.

### *Welding Position.*

Four gauge is the maximum electrode size recommended for fillet welds in the ordinary flat or downhand position. For 5/16" and 3/8" diameter electrodes the work must be tipped up at 45 degrees to bring the vee substantially to the upright position, the quantity of molten weld metal in the smallest advisable run being too great to control in any other position. Even with 4 gauge electrodes, better results are obtained by tipping up the work.

### *Welding Current.*

The recommended welding currents are as follows:—

| New Era (Extra Fluxed) Electrodes. | Amperes | | |
|---|---|---|---|
| | Normal. | Minimum. | Maximum. |
| 3/8" diameter | 520 | 470 | 570 |
| 5/16" „ | 410 | 370 | 450 |
| 4 gauge | 280 | 200 | 350 |
| General Purpose Electrodes. | | | |
| 3/8" diameter | 430 | 200 | 500 |
| 5/16" „ | 330 | 160 | 400 |
| 4 gauge | 250 | 140 | 330 |

### *Thickness of Plate and Size of Run.*

The limits of plate thickness and size of run are, if anything, more important for the heavy gauge than for medium gauge electrodes, to ensure both good welding and good quality weld metal. Thus multi-run welding may be necessary with the heavy gauge electrodes as in the case of lighter gauges, and, in fact, is recommended on account of the resulting beneficial heat treatment on the previous runs.

The saving in cost of welding with the use of heavy gauge electrodes is due to the increased rate of deposition of the weld metal. In equal times a 3/8" electrode will deposit approximately four times the quantity deposited by an 8 gauge electrode. The cost of cleaning off slag between runs is nearly always negligible, whereas the rate of deposition for a given quantity of weld metal may be slightly faster with a smaller sized run from a given gauge of electrode, as slightly higher currents can be used. The maximum size of fillet welds which may be deposited in one run are shown in the table below.

### *Recommended Gauge of Electrode and Length of Run.*

### *New Era (Extra Fluxed) Electrodes.*

| Plate Thickness | Electrode | Length of run in inches per electrode. | | Maximum size fillet in single runs. |
|---|---|---|---|---|
| | | Minimum. | Maximum. | |
| 5/8" and over | 3/8" dia. | 15 | 26 | 7/16" |
| 1/2" „ „ | 5/16" „ | 12 | 22 | 3/8" |
| 3/8" „ „ | 4 gauge | 10 | 18 | 5/16" |

### *General Purpose Electrodes.*

| Plate Thickness | Electrode | Length of run in inches per electrode. | | Maximum size fillet in single runs. |
|---|---|---|---|---|
| | | Minimum | Maximum | |
| 1/2" and over | 3/8" dia. | 13 | 32 | 1/2" |
| 3/8" „ „ | 5/16" „ | 12 | 26 | 7/16" |
| 3/8" „ „ | 4 gauge | 10 | 22 | 3/8" |

As the runs increase in length it becomes more difficult to obtain a nice shape and appearance of fillet.

Practical experience shows that it is usually advisable to put a good run of eight gauge electrode in the corner first, as this ensures a complete corner penetration not always obtainable with large gauge electrodes. If the work is then positioned, exceptionally nice fillets can be completed with one run of large gauge electrode.

## SECTION II.

# ELECTRODES FOR WELDING CAST IRON.

The following electrodes are supplied for welding cast iron:—

| Electrode. | Uses and Special Characteristics. |
|---|---|
| Cast Iron Hot | Deposits cast iron which is machinable after slow cooling. Preheating of the casting is essential. |
| Special Cast Iron | For depositing a machinable weld on cast iron without preheating. |
| Cast Iron Cold | For use only in cases where the casting cannot be preheated and where oxy-acetylene bronze welding is not practicable. |

### *Choice of Electrode.*

The use of the Cast Iron *Hot* Electrodes is limited to those cases where preheating to full redness and slow cooling are practicable and economical. Either the Special Cast Iron or Cast Iron *Cold* Electrodes may be used in other cases, the former in particular where machinability and strength are important.

### *Parent Metal.*

Success in welding depends not only on the shape and section of the casting, and the location and nature of the required weld, but also on the quality and condition of the cast iron.

More satisfactory results are obtained if the parent metal is good quality grey cast iron. If the cast iron has been subjected to the attack of acids or salt water, carbonized, oxidized, affected by heat or sulphur compounds, or otherwise deteriorated, it may be impossible to effect the welding.

When a casting has been exposed to oil, moisture, or gases for a prolonged period, it may have become impregnated with these materials, and this will render the metal apparently unweldable. In such cases, the weldability may be improved by holding the casting at a temperature of 300 to 400° C. for a period of a few hours, when the impregnated elements will be driven off. For this purpose, the first signs of redness in the casting should be taken as an indication that the maximum permissible temperature has been reached. If this temperature is exceeded to any extent, the casting may be hardened and embrittled unless cooled out slowly.

### *Welding Procedure.*

Careful and correct procedure is essential to overcome the inherent difficulty of welding cast iron due to expansion and contraction, and the change in form of the carbon content of the iron caused during the welding operation.

The effect of expansion and contraction is more serious in welding cast iron than in welding mild steel, on account of the lower tensile strength and negligible ductility of cast iron.

Admixture with the cast iron of a weld metal of lower carbon content results in what is virtually a partly quenched high carbon steel, which is of doubtful composition, usually brittle and "hot short," and unable to withstand contraction stresses on cooling.

The alteration of the carbon content from the free state, as graphite, to the combined state, as carbides, results in a change from machinable grey cast iron to hard unmachinable white iron. The main factor influencing this change, other than the composition of the cast iron, is the rate of cooling, which must be very slow in order to retain the carbon in the free state.

The procedure recommended for each type of electrode is detailed below.

## CAST IRON HOT ELECTRODES.

When "hot" welding cast iron with E.M.F. Cast Iron Hot Electrodes, which under the correct conditions deposit a good quality grey iron, the difficulties already discussed are to a great extent avoidable. Their use is not always advantageous, on account of the cost of preheating and the necessity of stripping the part for preheating, and is sometimes undesirable on account of the danger of subsequent distortion.

### *Strength Tests.*

Tensile tests on butt welds in 2" x ½" cast iron welded with E.M.F. Cast Iron Hot Electrodes have been made, and the specimens failed in the plate clear of the weld at an average stress of 10½ tons per square inch.

### *Welding Procedure.*

The work must be given a general preheat by some suitable means, the amount and location of the preheating being governed by the size and shape of the work and the location of the fracture. At the location of the weld the cast iron should be brought to a full cherry red heat, approximately 800 degrees Centigrade, before starting to deposit the electrode. If possible, welding should be carried on while the work is on the fire or some means taken to maintain an even heat whilst welding. If this cannot be done the welding should be interrupted at intervals and the work brought up to the correct heat again.

The electrode is held at right angles to the surface of the work and the arc is held short, to the extent of puddling the molten pool with the end of the electrode. This is necessary because the coating of the rods does not melt to a slag, but tends to flake off, part of the flakes being absorbed by the molten metal. Owing to the great fluidity of the molten metal there is little tendency for the electrode tip to stick or freeze to the work. The unabsorbed particles of electrode coating are in no way harmful, and there is no need to remove them between runs unless they accumulate in such a way that they are likely to become trapped in corners or craters.

After completion, the job should be cooled out slowly in the furnace, but if this is not possible, it should be covered with dry sawdust or lime.

The recommended welding currents are as follows:—

| Gauge | Amperes |
|---|---|
| 6 | 180 |
| 8 | 145 |
| 10 | 120 |
| 12 | 95 |

## SPECIAL CAST IRON ELECTRODES.

The weld metal deposited by these electrodes is a copper nickel alloy, and as any carbon and iron absorbed into it do not produce appreciable hardening, the weld metal is readily machinable. Since the melting point of the alloy is lower than that of Cast Iron, the temperature gradient is less, and the hard band formed in the iron adjacent to the weld is kept to a minimum.

Unlike mild steel weld metal, the molten alloy will not flow readily, and the weld metal must be puddled somewhat to "wet" the parent metal properly. Where possible the work should be warmed slightly before commencing to weld, otherwise the first half inch or so of a run may be a little porous. This is due to the rapidity of solidification, which prevents the escape of all the gas resulting from the reaction in the arc and liberated from the cast material. The puddling of the weld metal assists in the freeing of this gas.

The recommended welding currents are as follows:—

| Gauge. | Amperes. |
|---|---|
| 6 | 180 |
| 8 | 130 |
| 10 | 105 |
| 12 | 75 |

## CAST IRON COLD ELECTRODES.

The so-called "cold" welding of cast iron should be adopted only in those cases where the casting cannot be preheated, and where oxy-acetylene bronze welding is not practicable. It is not recommended for welding thin sections, or intricate castings.

To obtain any measure of success, the cast iron parent metal must be of good weldable quality.

### *Welding Procedure.*

Careful procedure must be adopted to minimize the difficulties inherent in welding cast iron, and to reduce to a minimum the narrow, hard, brittle, white iron zone formed adjacent to the weld. It is necessary to deposit the metal in small quick runs so that the heat applied is not great and the subsequent contraction is small, and so that the amount of added weld metal is small in comparison to the parent metal.

### *Machinability and Strength.*

Whilst the foregoing procedure which has been recommended may overcome the possibility of damage, due to contraction, and will minimize the difficulties arising from the forming of the hard weld junction and the white iron zone adjacent to the weld, this hard brittle zone will invariably be present. Thus cast iron cold welds cannot be guaranteed either for machinability or strength.

The recommended welding currents are as follows:—

| | Amperes | | |
|---|---|---|---|
| Gauge. | Normal. | Minimum. | Maximum. |
| 6 | 170 | 135 | 195 |
| 8 | 145 | 125 | 180 |
| 10 | 120 | 85 | 130 |
| 12 | 80 | 50 | 100 |

## SECTION III.

# ELECTRODES FOR WELDING CARBON AND ALLOY STEELS AND FOR HARD SURFACING.

The following types of electrodes are available for welding the above steels:—

| Electrode. | Uses and Special Characteristics. | Physical Properties. |
|---|---|---|
| Rail Rod | For medium hard surfacing and building up on carbon steel rails, points and crossings. The weld metal responds to heat treatment. | Tensile strength 35-40 tons per sq. in.<br>Izod shock value 16 ft. lbs. |
| High Carbon | For depositing a carbon steel on wearing surfaces, etc. The weld metal responds to heat treatment. | Tensile strength 46 tons per sq. in. |
| Hollite (426a)<br>No. 1<br>No. 2 | For hard surfacing. Deposit a hard, tough, dense weld metal. | |
| Nickel Steel | For welding or building up on nickel steel. The weld metal is amenable to case hardening treatment. | |
| Manganese | For building up on 12% to 14% manganese steel. | |
| Austerod | Deposits an austenitic steel. For welding on manganese crossings, manganese steel castings, etc. Deposited metal hardens with service. For general welding of 18/8 stainless steel, and welding manganese steel to mild steel. | |

## RAIL ROD ELECTRODES.

The physical properties shown in the table may be obtained in a multi-run weld, but the hardness of the weld metal will vary according to the conditions of deposition. If deposited on a comparatively cold surface the metal is chilled and consequently will be hard. If reheated by subsequent runs of weld, the previous runs will be slightly softened, but the last run of a multi-run weld will be hard.

Thus the hardness can be controlled to a certain extent by suitably controlling the heat conditions.

'The following test results indicate the approximate physical properties attained with welds which were subjected to heat treatment:—

| Treatment. | Ult. Ten. Strength Tons/sq. in. | Elongation on 4 dias. | Contraction in Area. | Brinell Hardness No. |
|---|---|---|---|---|
| Annealed | | | | |
| from 800° C. .. .. .. | 45.5 | 16% | 30% | 210 |
| ,, 930° C. .. .. .. | 48.5 | 14% | 20% | 210 |
| Quenched in Oil | | | | |
| from 800° C. .. .. .. | 53.0 | 2% | — | 410 |
| ,, 850° C. .. .. .. | — | — | — | 410 |
| ,, 900° C. .. .. .. | — | — | — | 410 |
| ,, 950° C. .. .. .. | — | — | — | 410 |
| Quenched in Oil from 800° C., and tempered at 300° C. .. | 45.0 | 7% | — | 360 |

When the metal is hardened there is a slight increase in tensile strength, but a marked reduction in ductility. By quenching in water from above 600° C. slightly greater hardness is obtained than by quenching in oil, but there is a tendency for cracks to develop.

A short arc should be held with the electrode at an angle of not less than 70 degrees to the plate.

The recommended welding currents are as follows:—

| Gauge | Amperes |
|---|---|
| 6 | 165 |
| 8 | 135 |
| 10 | 115 |
| 12 | 90 |

NOTE.—Electrodes to deposit weld metal containing varying percentages of carbon can be supplied.

## HIGH CARBON ELECTRODES.

If deposited in a multi-run weld, the metal is very tough and has a tensile strength of 45 tons per square inch. The hardness of the weld metal will vary according to the conditions of deposition. If deposited on a comparatively cold surface, the metal will be chilled and consequently harder. If reheated by subsequent runs of welding the previous runs will be softened slightly and the last run of a multi-run weld will be hard. Thus the hardness can be controlled to a certain extent by suitably controlling the heat conditions.

The following test results indicate the approximate physical properties attained with welds which were subjected to heat treatment:—

| Treatment. | Ult. Ten. Strength Tons/sq. in. | Elongation on 4 dias. | Contraction in Area. | Brinell Hardness No. |
|---|---|---|---|---|
| Annealed from 800° C. | 45 | 25% | 41% | 210 |
| Quenched in Oil from 800° C. | — | — | — | 440 |
| „ 850° C. | — | — | — | 440 |
| „ 900° C. | — | — | — | 440 |
| „ 950° C. | — | — | — | 440 |
| Quenched in Oil from 800° C., and tempered at 300° C. | 90.0 | 1.5% | — | 415 |

From these results it appears that no appreciable difference in hardness is obtained by varying the quenching temperatures. By quenching in water from above 800° C. slightly greater hardness is obtained than by quenching in oil, but there is a tendency for cracks to develop.

A short arc should be held with the electrode at an angle of not less than 70 degrees to the plate.

The recommended welding currents are as follows:—

| Gauge | Amperes |
|---|---|
| 6 | 165 |
| 8 | 135 |
| 10 | 115 |
| 12 | 90 |

NOTE.—Electrodes to deposit weld metal containing varying percentages of carbon can be supplied.

## HOLLITE ELECTRODES.

E.M.F. Hollite Electrodes deposit a self-hardening chromium steel and are useful for hard surfacing and tipping in such work as building up shear blades, dies, crusher jaws, etc.

The weld metal deposited by these electrodes is hard and tough. A single bead of welding deposited on cold plate will have a Brinell Hardness of 500, but in multiple run pads the weld metal will be softer. In the annealed condition, the hardness of the metal is approximately 300, and this will increase with cold working up to 450 Brinell.

By quenching in oil or water various degrees of hardness can be obtained with Hollite (426A), as follows:—

Quenched from 800° C. in water, Brinell Hardness No. 440
" " 900° " " " " 510
" " 1000° " " " " 550

Lower figures are obtained if oil is used as a quenching medium.

As stated, these figures refer only to Hollite (426A), and different heat treatment is required with Hollite No. 1 or 2.

Owing to the fluid nature of the weld metal it is sometimes found necessary to use carbon block moulds to retain metal where required. The blocks should be preheated and properly earthed to assist the moulding of the weld metal.

Hollite No. 1 Electrodes deposit a medium carbon chrome steel and are useful for the building up of dies, particularly where the whole job can be preheated and the metal deposited between carbon blocks or moulds, the whole job being quenched immediately after welding or from a temperature above 900° C. The deposited metal can then be ground to the required shape.

Hard facing, where similar heat treatment is possible, will also prove satisfactory.

Hollite No. 1 may also be used for the building up of parts subject to abrasion, as in coal and coke crushing or handling plants. Dredge buckets, particularly if subjected to abrasive rather than very heavy shock stresses, give very satisfactory service if faced with this electrode.

If working in heavy rock country, dredge buckets may give better service if faced with Hollite (426a) or Manganese Steel Electrodes, which have better work hardening properties and toughness than either Hollite No. 1 or No. 2.

Hollite No. 2 is generally satisfactory in the same field as Hollite No. 1, but should be used where greater hardness is required, as it deposits a steel of higher carbon and chromium content.

The recommended welding currents for the three types of Hollite electrodes are as follows:—

| | Amperes | | |
|---|---|---|---|
| Gauge. | 426a. | No. 1. | No. 2. |
| 6 | 170 | 175 | 165 |
| 8 | 140 | 145 | 135 |
| 10 | 105 | 125 | 115 |
| 12 | 80 | 100 | 90 |

## NICKEL STEEL ELECTRODES.

E.M.F. Nickel Steel Electrodes are suitable for welding steels containing Carbon up to 0.3%, Nickel up to 5%, and Chromium up to 1%.

The electrode is also suitable for building up wearing surfaces requiring a tough, sound metal and is very suitable for work which is to be case hardened. The Brinell Hardness No. of a multiple run pad weld which has been allowed to cool naturally in air will be 180-200, but single runs on cold plate will be harder.

As these steels respond readily to heat treatment, the heat conditions of the work both during and after welding must be suitably controlled. For strength welds it is necessary to preheat the work to between 300° and 400° C., remove from furnace (or fire), make the weld and return to furnace to equalise the heat throughout the work, and then allow to cool in air or proceed with heat treatment if desired.

The recommended welding currents are as follows:—

| Gauge | Amperes |
|---|---|
| 8 | 160 |
| 10 | 120 |
| 12 | 80 |

Within practical limits the current may be varied above or below the average figure given.

## MANGANESE STEEL ELECTRODES.

These electrodes are suitable for repairs to manganese steel castings and for building up wearing surfaces on such castings.

The deposited metal has a composition of 11-13% Manganese and 1.0-1.3% Carbon, and is equal to cast manganese steel in hardness and work-hardening properties.

The electrodes are not suitable for building up on mild steel except in special circumstances, the reason being that in such a weld there is a zone below the weld metal in which the steel will be in a brittle condition.

### *Welding Procedure.*

The weld metal should be deposited in short runs of not more than 3 inches in length by using a puddling motion of the electrode, and the work kept cool by dousing with water after each run. It is important to hammer each run thoroughly before it has cooled below red heat to avoid contraction cracks. This should be done quickly without losing time in removing the slag.

The recommended welding currents are as follows:—

| Gauge | Amperes |
|---|---|
| 6 | 180 |
| 8 | 165 |
| 10 | 115 |

## AUSTEROD (STAINLESS STEEL) ELECTRODES.

These electrodes deposit an 18/8 stainless steel with non-corrosive properties equal to those of ordinary steels of this composition. Their uses are for welding austenitic stainless steels or for building up wearing surfaces, especially on 11-14% manganese steel castings such as railway and tramway crossings. The weld metal will work-harden and resist wear similarly to manganese steel.

### *Welding Procedure.*

For welding stainless steel see general notes under heading " E.M.F. Electrodes for Welding Stainless and Heat Resisting Austenitic Steels " on page 34.

For welding on manganese steel, rapid cooling of the weld metal is desirable. To ensure this the weld metal should be deposited in short runs. The parent metal should not be more than hand warm before a run is made, and to maintain this condition frequent dousing with cold water is often necessary, but the water should be dried off

**before adding further runs. Each run should be well peened before proceeding to make another.**

**The recommended welding currents are as follows:—**

| | Amperes | | |
|---|---|---|---|
| **Gauge.** | Normal. | Minimum. | Maximum. |
| **6** | 170 | 130 | 200 |
| **8** | 140 | 100 | 175 |
| **10** | 105 | 70 | 130 |
| **12** | 80 | — | — |
| **14** | 50 | — | — |
| **16** | 35 | — | — |

## SECTION IV.

# ELECTRODES FOR WELDING STAINLESS AND HEAT RESISTING AUSTENITIC STEELS.

E.M.F. Electrodes are supplied for welding the following steels:

Messrs. Firth Vickers Stainless Steels—
- Staybrite F.S.T.
- Staybrite F.D.P.
- Staybrite F.M.B.

Messrs. Brown Bayley Steel Works Ltd.—Weldanka.

Messrs. Poldi Steel Co.—
- A.K.V.N. (Stainless).
- A.K.C.B. (Heat Resisting).

The electrodes are known by the names of the various steels listed above. E.M.F. Austerods are also available for the welding of Chrome Nickel castings.

Electrodes for welding other makes of stainless and heat resisting steels can be supplied on application.

### *Selection of Steel.*

The name " Stainless Steel " covers a wide range of corrosive and heat resisting steels, and although practically all are readily weldable as far as the actual operation is concerned, all, by no means, weld satisfactorily.

Austenitic stainless steels, i.e., those containing high percentages of both chromium and nickel, are the most suitable for welding, but with many of these, the application of heat by welding or any other means will cause embrittlement and loss of corrosive resisting properties. To overcome this difficulty, special weldable grades have been developed by the makers, so that unless subsequent heat treatment is intended, the buyer should specify " Welding Quality " when placing orders for the steel.

These weldable austenitic stainless steels are softened by rapid cooling from high temperatures while other steels are hardened by this treatment.

Non-austenitic stainless steels as a rule can only be welded successfully if full details of the composition are known and the proper heat treatment is applied.

### *Welding Procedure.*

Particular care should be taken with the preparation for welding. The plate should be freed from all foreign matter, such as paint, grease, etc., which would tend to contaminate the weld metal.

The maximum limit for welding current as set out on the package labels should not be exceeded, as the high electrical resistance of steels of this type renders the electrodes liable to overheating.

Less current than is usual in welding mild steel is required as stainless steels are poorer conductors of heat than mild steel, and therefore the heat of welding is retained more locally and proper penetration is more easily obtained. As the co-efficient of expansion is about half as great again as in mild steel and the strength is greater, more elaborate precautions must be taken against distortion.

### *Treatment After Welding.*

The special weldable grades need no subsequent heat treatment, but other austenitic stainless steels must be heat treated after welding if the maximum physical and non-corrosive properties are to be expected.

The heat treatment necessary is as follows:—

The steel should be held at between 900° and 1100° C. for not less than 15 minutes after the temperature has become uniform, and then cooled rapidly by quenching in water. Quenching from the higher temperature limit is preferable.

If maximum resistance to corrosion is desired any heat discolouration must be removed by grinding, machining or by a descaling solution as recommended by the steel makers.

One descaling solution is as follows:—

| | |
|---|---|
| 45% | Hydrochloric Acid. |
| 5% | Nitric Acid. |
| 50% | Water (approximately). |
| ½% | Restrainer. |

Care should be taken that this solution does not become fouled, or weak. The restrainer is a special proprietary preparation which restrains the tendency of the acid solution to pit the steels. When unobtainable, wheaten flour will serve as a substitute.

The solution should be used warm, between 110° and 140° F. The articles should not be left in the solution longer than is necessary to loosen the stains, which should then be scrubbed off. After descaling, articles should be washed and all traces of acid neutralised by an immersion in a hot alkaline bath of soda-ash solution or water carrying excess lime.

By the use of other pickling solutions, different surface finishes can be obtained. Formulae for these can be obtained from the suppliers of the steel.

### *Welding Current.*

The recommended welding currents are as follows:—

| Gauge | Amperes |
|---|---|
| 6 | 170 |
| 8 | 135 |
| 10 | 100 |
| 12 | 70 |
| 14 | 50 |
| 16 | 35 |
| 18 | 20 |

## SECTION V.

## ELECTRODES FOR WELDING MONEL METAL.

E.M.F. Monel Metal Electrodes deposit a true Monel metal which, when peened, has physical and corrosive resisting properties equal to the rolled material.

As deposited, the weld metal has a columnar crystalline structure, which cannot be refined by heat treatment, but which can be corrected by cold working. For this reason each run of weld deposited should be well hammered as soon as it has cooled below red heat. This peening also serves to relieve contraction stresses and to lessen the possibility of cracks during cooling, the weld metal being "hot short," although very ductile when cold.

Unlike mild steel weld metal, Monel metal will not flow readily, and the weld metal must be puddled somewhat to "wet" the parent metal properly. The work should be warmed slightly before commencing to weld, otherwise the first 1/2" or so of a run may show holes on the surface of the bead. This is due to the rapidity of solidification, which prevents the escape of all the gas resulting from the reaction in the arc. The puddling of the weld metal assists in the freeing of this gas.

The recommended welding currents are as follows:—

| Gauge | Amperes |
|---|---|
| 6 | 180 |
| 8 | 130 |
| 10 | 105 |
| 12 | 75 |
| 14 | 50 |
| 16 | 35 |

## SECTION VI.

# CUTTING ELECTRODES.

E.M.F. Cutting Electrodes are intended for cutting steel in inaccessible places, or where other means are not available.

If the electrodes are properly used, no metal will be deposited. The slag and oxidised metal can be readily knocked off, leaving a fairly clean cut, but much wider than that usually made with the oxy-acetylene torch.

High current is essential. Cutting should, where possible, be commenced on the edge of the plate, and the arc played up and down the advancing end of the cut. The electrode should be held at an acute angle to the plate. This is facilitated by the width of the cut made, which will be wide enough to admit the covered rod when it is necessary to reach the lower edge of the cut with the arc. The coating is a good insulator and will not arc on the sides of the cut.

To blow a hole the arc is concentrated on one place, using moderately hard pressure on the electrode. This will not short the arc, as the crater formed on the electrode tip by the coating maintains the correct arc length. The melted metal should not be puddled, but steadily increasing pressure applied until the arc blows right through the plate. The hole can then be enlarged or extended into a cut if required. The blowing of holes requires a little practice, but once the knack is acquired presents no difficulties.

This method of cutting cannot compete with the oxy-acetylene torch either in speed, neatness, or cost, and is not intended to replace the torch, but for emergency cuts a packet of cutting rods will be found to be a useful accessory in the welder's kit.

The electrodes may be used with either A.C. or D.C., and, when used with the latter, the work must be on the negative and the electrode on the positive pole.

## LIST OF E.M.F. ELECTRODES

Pages 40, 41.

## DESIGN DATA FOR NEW ERA ELECTRODES

Pages 42, 43.

# LIST OF E.M.F. ELECTRODES

| E.M.F. Electrodes | Gauge | Average Current Amps. | Uses and Special Features. | Cases. | | | Colouring. | | Code Word |
|---|---|---|---|---|---|---|---|---|---|
| | | | | Contents Feet | Gauge | Approx. Gross Weight lbs. | Flux | Tip | |
| **NEW ERA (Extra Fluxed)** | 3/8" | 520 | For important welding on mild steel in structural work, machinery, etc. Recommended for welds carrying high stresses or subject to impact or fatigue loading. It is suitable for boiler work and can be forged. Under good conditions will produce smooth neat welds. The electrode complies with the S.A.A. Code requirements for Structural Grade Electrodes and Lloyd's specification for electrodes for welding of primary structural importance. *18" lengths (12g. 18" or 12").* | 200 | 3/8" | 100 | Black | Purple | FLUX |
| | 5/16" | 410 | | 200 | 5/16" | 75 | | | |
| | 4 | 280 | | 600 | 4 | 123 | | | |
| | 6 | 190 | | 800 | 6 | 113 | | | |
| | 8 | 160 | | 1200 | 8 | 114 | | | |
| | 10 | 120 | | 1500 | 10 | 92 | | | |
| | 12 | 85 | | 1800 | 12 | 77 | | | |
| **NEW ERA (Vertical)** | 6 | 180 | Exceptionally suitable for welding vertically down. The electrode complies with the S.A.A. Code requirements for Structural Grade Electrodes and Lloyd's specification for electrodes for welding of primary structural importance. *18" lengths.* | 800 | 6 | 100 | Black | Blue | ERA |
| | 8 | 145 | | 1200 | 8 | 110 | | | |
| | 10 | 125 | | 1500 | 10 | 90 | | | |
| | 12 | 85 | | 1800 | 12 | 77 | | | |
| **GENERAL PURPOSE** | 3/8" | 430 | Suitable for welding mild steel in all positions. The electrode complies with the S.A.A. Code requirements for Structural Grade Electrodes. | 200 | 3/8" | 95 | Beige | Yellow | GEPUR |
| | 5/16" | 330 | | 200 | 5/16" | 70 | | | |
| | 4 | 250 | | 600 | 4 | 115 | | | |
| | 6 | 180 | | 800 | 6 | 105 | | | |
| | 8 | 145 | | 1200 | 8 | 93 | | | |
| | 10 | 110 | | 1500 | 10 | 84 | | | |
| | 12 | 70 | *18" lengths (12g. 18" or 12").* | 1800 | 12 | 70 | | | |
| | 14 | 45 | *12" lengths.* | 3600 | 14 | 78 | | | |
| | 16 | 25 | | 6000 | 16 | 89 | | | |
| **WELD ROD** | 4 | 260 | For general welding of mild steel. A good mild steel electrode having easy running characteristics giving exceptionally smooth finished welds, but having physical characteristics slightly below those of New Era | 600 | 4 | 120 | Black | Orange | WELD |
| | 6 | 190 | | 800 | 6 | 109 | | | |
| | 8 | 160 | | 1200 | 8 | 112 | | | |
| | 10 | 120 | | 1500 | 10 | 89 | | | |
| | 12 | 80 | *18" lengths (12g. 18" or 12").* | 1800 | 12 | 75 | | | |
| **● MILD STEEL** | 4 | 200 | A general purpose electrode for welding mild steel and wrought iron. Suitable for overhead and vertical welding. *18" lengths.* | 600 | 4 | 111 | Reddish Brown | Yellow | STEEL |
| | 6 | 180 | | 800 | 6 | 109 | | | |
| | 8 | 145 | | 1200 | 8 | 116 | | | |
| | 10 | 125 | | 1500 | 10 | 106 | | | |
| | 12 | 80 | | 1800 | 12 | 89 | | | |
| Any of the above electrodes can be supplied to deposit weld metal containing 0.3% copper, or any other percentage to specification | | | | | | | | | |
| **ARC ROD** | 4 | 190 | For work where low cost is necessary and first-class quality not essential. *18" lengths.* | 900 | 4 | 140 | Black | Yellow | ARC |
| | 6 | 160 | | 1200 | 6 | 133 | | | |
| | 8 | 130 | | 1800 | 8 | 140 | | | |
| | 10 | 100 | | 2700 | 10 | 134 | | | |
| | 12 | 70 | | 3600 | 12 | 118 | | | |
| | 14 | 50 | | 7200 | 14 | 138 | | | |
| **SHEET STEEL** | 14 | 50 | For welding sheet mild steel *12" lengths.* | 3600 | 14 | 86 | Grey | Pale Blue | SHEET |
| | 16 | 35 | | 6000 | 16 | 97 | | | |
| | 18 | 20 | *9" lengths.* | 8000 | 18 | 70 | | | |
| * **● CAST IRON HOT** | 6 | 180 | Deposits cast iron which is machinable after slow cooling Preheating of the casting is essential. *18" lengths.* | 600 | 6 | 82 | Dark Grey | Black | HOT |
| | 8 | 145 | | 800 | 8 | 82 | | | |
| | 10 | 120 | | 1200 | 10 | 84 | | | |
| | 12 | 95 | | 1500 | 12 | 77 | | | |
| * **SPECIAL CAST IRON** | 6 | 180 | For depositing a machinable weld on cast iron without preheating *12" lengths.* | 800 | 6 | 113 | Dark Grey | Bright | SPAST |
| | 8 | 130 | | 1200 | 8 | 124 | | | |
| | 10 | 105 | | 1500 | 10 | 99 | | | |
| | 12 | 75 | | 1800 | 12 | 83 | | | |
| **● CAST IRON COLD** | 6 | 170 | For use only in cases where the casting cannot be preheated and where oxy-acetylene bronze welding is not practicable. *18" lengths.* | 800 | 6 | 110 | Dark Brown | Silver Grey | COLD |
| | 8 | 145 | | 1200 | 8 | 118 | | | |
| | 10 | 120 | | 1500 | 10 | 103 | | | |
| | 12 | 95 | | 1800 | 12 | 93 | | | |

● These Electrodes are of the special E.M.F. wire bound type and deposit more metal per electrode than the other types, to the following extent:—

12.G.–30%
10.G.–20%
8.G.–15%
6.G.–10%

# LIST OF E.M.F. ELECTRODES

| E.M.F. Electrodes | Gauge | Average Current Amps. | Uses and Special Features. | Cases. | | | Colouring. | | Code Word |
|---|---|---|---|---|---|---|---|---|---|
| | | | | Contents Feet | Gauge | Approx Gross Weight lbs. | Flux | Tip | |
| ● RAIL ROD | 6 | 165 | For medium hard surfacing and building up on carbon steel rails, points and crossings. The weld metal responds to heat treatment *18" lengths.* | 800 | 6 | 109 | Black | Red | RAIL |
| | 8 | 135 | | 1200 | 8 | 120 | | | |
| | 10 | 115 | | 1500 | 10 | 107 | | | |
| | 12 | 90 | | 1800 | 12 | 97 | | | |
| ● HIGH CARBON | 6 | 165 | For depositing a carbon steel on wearing surfaces, etc. The weld metal responds to heat treatment. *18" lengths.* | 800 | 6 | 109 | Black | Grey | CARB |
| | 8 | 135 | | 1200 | 8 | 120 | | | |
| | 10 | 115 | | 1500 | 10 | 107 | | | |
| | 12 | 90 | | 1800 | 12 | 97 | | | |
| HOLLITE (426a) | 6 | 170 | For hard surfacing. Deposit a hard, tough, dense weld metal. *(426a) 12" lengths.* *Nos. 1 and 2 18" lengths.* | 800 | 6 | 113 | Grey | Green | HOLIT * |
| ● HOLLITE No.1 | 8 | 140 | | 1200 | 8 | 114 | Dark Grey | | HOLON * |
| | 10 | 105 | | 1500 | 10 | 92 | | | |
| ● HOLLITE No.2 | 12 | 80 | | 1800 | 12 | 77 | Black | | HOTWO * |
| NICKEL STEEL | 8 | 160 | For welding or building up on nickel steel. The weld metal is amenable to case hardening treatment. *18" lengths.* | 1200 | 8 | 113 | Black | Bright | NIKEL |
| | 10 | 120 | | 1500 | 10 | 94 | | | |
| | 12 | 80 | | 1800 | 12 | 76 | | | |
| ● MANGANESE | 6 | 180 | For building up on 12-14% manganese steel. *18" lengths.* | 600 | 6 | 96 | Grey | Pink | MANG * |
| | 8 | 165 | | 800 | 8 | 96 | | | |
| | 10 | 115 | | 1200 | 10 | 92 | | | |
| AUSTEROD | 6 | 170 | Deposits an austenitic steel. For welding on manganese crossings, manganese steel castings, etc. Deposited metal hardens with service. For general welding of 18/8 stainless steel, and welding manganese steel to mild steel. *12" lengths.* | 800 | 6 | 99 | White | Lavender | AUSTE * |
| | 8 | 140 | | 1500 | 8 | 126 | | | |
| | 10 | 105 | | 1800 | 10 | 103 | | | |
| | 12 | 80 | | 2100 | 12 | 86 | | | |
| | 14 | 50 | | 4000 | 14 | 101 | | | |
| | 16 | 35 | | 6000 | 16 | 98 | | | |
| STAYBRITE F.S.T. | 8 | 135 | For welding Firth-Vickers F.S.T., F.D.P., and F.M.B. Staybrite steels. *12" lengths.* | 1500 | 8 | 129 | White | Pale Pink | F.S.T. * |
| | 10 | 100 | | 1800 | 10 | 102 | | | |
| | 12 | 70 | | 2100 | 12 | 89 | | | |
| F.D.P. | 14 | 50 | | 4000 | 14 | 101 | White | Pale Blue | F.D.P. * |
| | 16 | 35 | | 6000 | 16 | 98 | | | |
| F.M.B. | 18 | 20 | *9" lengths.* | 8000 | 18 | 70 | White | Orange | F.M.B. * |
| WELDANKA | 8 | 135 | For welding Brown Bayley Weldanka stainless steel. *12" lengths.* | 1500 | 8 | 125 | White | Light Yellow | ANKA * |
| | 10 | 100 | | 1800 | 10 | 105 | | | |
| | 12 | 70 | | 2100 | 12 | 89 | | | |
| | 14 | 50 | | 4000 | 14 | 101 | | | |
| | 16 | 35 | | 6000 | 16 | 98 | | | |
| POLDI A.K.V.N. | 6 | 170 | For welding Poldi A.K.V.N. "Anticorro" steel. *12" lengths.* | 800 | 6 | 99 | White | Light Green | POLDN * |
| | 8 | 135 | | 1500 | 8 | 125 | | | |
| | 10 | 100 | | 1800 | 10 | 105 | | | |
| | 12 | 70 | | 2100 | 12 | 89 | | | |
| | 14 | 50 | | 4000 | 14 | 101 | | | |
| | 16 | 35 | | 6000 | 16 | 98 | | | |
| POLDI A.K.C.B. | 8 | 135 | For welding Poldi A.K.C.B. heat resisting steel. *12" lengths.* | 1500 | 8 | 125 | Light Grey | Light Brown | POLDC * |
| | 10 | 100 | | 1800 | 10 | 105 | | | |
| | 12 | 70 | | 2100 | 12 | 89 | | | |
| | 14 | 50 | | 4000 | 14 | 101 | | | |
| MONEL METAL | 6 | 180 | For welding monel metal. *12" lengths.* | 800 | 6 | 113 | Black | Green | MONEL * |
| | 8 | 130 | | 1200 | 8 | 124 | | | |
| | 10 | 105 | | 1500 | 10 | 99 | | | |
| | 12 | 75 | | 1800 | 12 | 83 | | | |
| | 14 | 50 | | 3600 | 14 | 85 | | | |
| | 16 | 35 | | 6000 | 16 | 97 | | | |
| CUTTING ROD | 6 | 360 | For Arc Cutting. Specially suitable for removing headers from stainless and heat resisting steel castings. *18" lengths.* | 600 | 6 | 84 | White | Bare End | CUT |
| | 8 | 270 | | 600 | 8 | 66 | | | |
| | 10 | 190 | | 800 | 10 | 56 | | | |

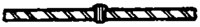
**Special Electrodes.**—Electrodes for special purposes can be supplied if the quantity warrants manufacture.

E.M.F. Electrodes are wrapped in moisture-proof Packages containing 100 feet, except Arc Rods, 150 feet, and items marked * in list, which are in 50 feet Packages. Average weight of empty cases, 8½ lbs.

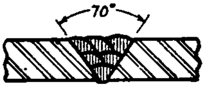
# E.M.F. NEW ERA ELECTRODES

## DESIGN DATA

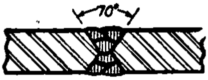
To Conform with S.A.A. Code Ca 8—1933.



*No Preparation*
*Plain Butt.*



*Single Vee Butt.*



*Double Vee Butt.*

## BUTT WELDS.

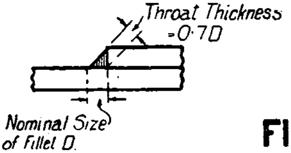
| Plate Thickness. | Preparation. | Strength Per Lin. Inch of Weld |  | Particulars of Welding |  |  |  |  |  |  | Total Cost Per Foot of Weld. 70° Vee |  |  |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
|  |  | Ultimate Strength | Working Stress SAAcode | Number and Length of Run | Gauge | Feet of Electrode per foot of Weld. | Welding Current | Power Consumption per ft. of Weld. | Welding Time per foot of weld: Nett | Welding Time per foot of weld: Average Practical Time | Down hand | Vert. Add 10% | O'head Add 15% |
| Inches |  | Tons | Tons |  | S.W.G. | Feet | Amps. | KW.Hrs. | Min. | Min. | Pence | Pence | Pence |
| 1/8 | Plain. | 3·5 | 0·9 | 1–12/10 | 12⁘ | 1·8 | 90 | ·11 | 2 | 4 |  |  |  |
| 3/16 | Plain. | 5·2 | 1·3 | 1–10/8 | 10 | 2·3 | 110 | ·22 | 2·5 | 5 |  |  |  |
|  |  |  |  | 1–8/15 | 8 | 1·2 | 140 |  | 1·5 | 3 |  |  |  |
| 1/4 | Single Vee | 7·0 | 1·7 | 2–10/7 | 10 | 5·1 | 120 | ·43 | 5 | 10 |  |  |  |
|  |  |  |  | 2–8/12 | 8 | 3·0 | 150 |  | 3·5 | 7 |  |  |  |
| 5/16 | Single Vee | 8·7 | 2·2 | 3–10/8 | 10 | 6·8 | 120 | ·56 | 6·5 | 13 |  |  |  |
|  |  |  |  | 2–8/8 | 8 | 4·5 | 160 |  | 5 | 10 |  |  |  |
|  |  |  |  | 1–8/15 | 8 | 1·0 | 160 |  | 3·5 | 7 |  |  |  |
|  |  |  |  | 1–6/12 | 6⁘ | 1·5 | 190 |  |  |  |  |  |  |
| 3/8 | Single Vee | 10·5 | 2·6 | 3–10/6 | 10 | 9·0 | 120 | ·77 | 9 | 18 |  |  |  |
|  |  |  |  | 3–8/9 | 8 | 6·0 | 160 |  | 7 | 14 |  |  |  |
|  |  |  |  | 1–8/12 | 8 | 1·5 | 160 |  | 5·5 | 11 |  |  |  |
|  |  |  |  | 2–6/13 | 6 | 3·0 | 190 |  |  |  |  |  |  |
| 1/2 | Single Vee | 14·0 | 3·5 | 6–8/12 | 8 | 9·0 | 160 | 1·1 | 10 | 20 |  |  |  |
|  |  |  |  | 1–8/12 | 8 | 1·5 | 160 |  | 8·5 | 17 |  |  |  |
|  |  |  |  | 3–6/10 | 6 | 5·4 | 190 |  |  |  |  |  |  |
|  |  |  |  | 1–8/12 | 8 | 1·5 | 160 |  | 7 | 14 |  |  |  |
|  |  |  |  | 3–4/13 | 4 | 4·1 | 280 |  |  |  |  |  |  |
|  | Double Vee | 14·0 | 3·5 | 4–8/12 | 8 | 6·0 | 160 | ·71 | 7 | 14 |  |  |  |
|  |  |  |  | 2–8/12 | 8 | 2·8 | 160 |  | 7 | 14 |  |  |  |
|  |  |  |  | 2–6/12 | 6 | 2·8 | 190 |  |  |  |  |  |  |
| 5/8 | Single Vee | 17·5 | 4·4 | 10–8/11 | 8 | 16·4 | 160 | 2·0 | 13 | 26 |  |  |  |
|  |  |  |  | 1–8/12 | 8 | 1·5 | 160 |  | 12 | 24 |  |  |  |
|  |  |  |  | 6–6/13 | 6 | 7·6 | 190 |  |  |  |  |  |  |
|  |  |  |  | 1–8/12 | 8 | 1·5 | 160 |  | 9 | 18 |  |  |  |
|  |  |  |  | 5–4/15 | 4 | 5·5 | 280 |  |  |  |  |  |  |
|  | Double Vee | 17·5 | 4·4 | 6–8/11 | 8 | 9·8 | 160 | 1·2 | 11 | 22 |  |  |  |
|  |  |  |  | 2–8/13 | 8 | 2·8 | 160 |  | 8·5 | 17 |  |  |  |
|  |  |  |  | 3–6/13 | 6 | 3·8 | 190 |  |  |  |  |  |  |
|  |  |  |  | 2–8/12 | 8 | 2·7 | 160 |  | 7 | 14 |  |  |  |
|  |  |  |  | 2–4/12 | 4 | 2·7 | 280 |  |  |  |  |  |  |
| 3/4 | Single Vee | 21·0 | 5·2 | 15–8/11 | 8 | 24·6 | 160 | 3·0 | 27 | 54 |  |  |  |
|  |  |  |  | 1–8/10 | 8 | 6·1 | 160 |  | 19 | 38 |  |  |  |
|  |  |  |  | 9–6/12 | 6 | 8·2 | 190 |  |  |  |  |  |  |
|  |  |  |  | 1–8/9 | 8 | 1·8 | 160 |  | 15 | 30 |  |  |  |
|  |  |  |  | 6–4/11 | 4 | 9·4 | 280 |  |  |  |  |  |  |
|  | Double Vee | 21·0 | 5·2 | 6–8/7 | 8 | 15·4 | 160 | 1·7 | 17 | 34 |  |  |  |
|  |  |  |  | 2–8/12 | 8 | 2·7 | 160 |  | 12 | 24 |  |  |  |
|  |  |  |  | 5–6/14 | 6 | 6·1 | 190 |  |  |  |  |  |  |
|  |  |  |  | 2–8/13 | 8 | 2·8 | 160 |  | 8·5 | 17 |  |  |  |
|  |  |  |  | 4–4/13 | 4 | 4·7 | 280 |  |  |  |  |  |  |

* * *

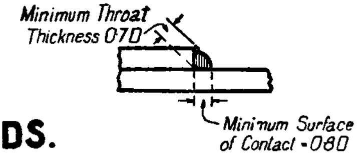
# E.M.F. NEW ERA ELECTRODES

## DESIGN DATA

To Conform with S.A.A. Code CA 8—1933.



## FILLET WELDS.



| Nominal Size of Fillet | Throat Thickness. | Strength Per Lin. In. of Weld | | | | | | Plate Thickness | Particulars of Welding. | | | | | | | Total Cost per Foot of Weld | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | End Welds | | | Side Welds | | | | Number and Length of Run | Gauge. | Feet of Electrode per Foot of Weld | Welding Current | Power Consumption per Foot of Weld | Welding time Per Foot of Weld | | | | |
| | | Ultimate Strength | Working Stress F of S 4 | Working Stress S.A.A. code | Ultimate Strength | Working Stress F of S 4 | Working Stress S.A.A. code | | | | | | | Nett | Average practical time | Down hand | Vertical Add 10% | O'head Add 15% |
| Inches | Inches | Tons | Tons | Tons | Tons | Tons | Tons. | Inches. | | S.W.G. | Feet | Amps | KW.Hrs | Min | Min | Pence | Pence | Pence |
| $\frac{3}{16}$ | 0·13 | 5·2 | 1·3 | **0·91** | 3·6 | 0·9 | **0·73** | $\frac{3}{16}$ to $\frac{3}{8}$ | 1—10/8 | **10** | 2·3 | 110 | 0·19 | 2·5 | 5·0 | | | |
| | | | | | | | | $\frac{1}{4}$ to $\frac{1}{2}$ | 1—8/11 | **8** | 1·6 | 150 | | 2 | 4 | | | |
| $\frac{1}{4}$ | 0·18 | 6·0 | 1·5 | **1·26** | 4·2 | 1·15 | **1·01** | $\frac{1}{4}$ to $\frac{3}{8}$ | 1—10/6 | **10** | 3·0 | 120 | 0·25 | 3 | 6 | | | |
| | | | | | | | | $\frac{1}{4}$ to $\frac{1}{2}$ | 1—8/8 | **8** | 2·3 | 160 | | 2·5 | 5 | | | |
| | | | | | | | | $\frac{3}{8}$ & over. | 1—6/14 | **6** | 1·3 | 200 | | 1·5 | 3 | | | |
| $\frac{5}{16}$ | 0·22 | 7·0 | 1·7 | **1·54** | 5·1 | 1·3 | **1·23** | $\frac{5}{16}$ to $\frac{3}{8}$ | 1—10/9<br>1—10/6 | **10** | 5·0 | 120 | 0·33 | 5 | 10 | | | |
| | | | | | | | | $\frac{5}{16}$ to $\frac{1}{2}$ | 1—8/11<br>1—8/9 | **8** | 3·6 | 160 | | 4 | 8 | | | |
| | | | | | | | | $\frac{3}{8}$ & over. | 1—6/9 | **6** | 2·0 | 200 | | 2·5 | 5 | | | |
| | | | | | | | | $\frac{3}{8}$ & over. | 1—4/13 | **4** | 1·4 | 250 | | 2 | 4 | | | |
| $\frac{3}{8}$ | 0·27 | 8·2 | 2·0 | **1·89** | 6·0 | 1·5 | **1·51** | $\frac{3}{8}$ & over. | 3—10/8 | **10** | 6·8 | 120 | 0·57 | 6·5 | 13 | | | |
| | | | | | | | | | 3—8/11 | **8** | 4·9 | 160 | | 5·5 | 11 | | | |
| | | | | | | | | | 1—8/15+1/6-10<br>or 3—6/15 | **6** | 3·6 | 200 | | 4 | 8 | | | |
| | | | | | | | | | 1—4/18<br>1—4/15 | **4** | 2·2 | 250 | | 2·5 | 5 | | | |
| $\frac{1}{2}$ | 0·35 | 10·4 | 2·6 | **2·45** | 8·0 | 2·0 | **1·95** | $\frac{1}{2}$ & over. | 3—8/6·5 | **8** | 8·0 | 160 | 0·95 | 9 | 18 | | | |
| | | | | | | | | | 3—6/10 | **6** | 5·4 | 200 | | 6·5 | 13 | | | |
| | | | | | | | | | 3—4/14 | **4** | 3·9 | 250 | | 5 | 10 | | | |
| $\frac{5}{8}$ | 0·44 | 12·6 | 3·1 | **3·08** | 10·0 | 2·5 | **2·46** | $\frac{5}{8}$ & over. | 5—8/7 | **8** | 12·8 | 160 | 1·48 | 14 | 28 | | | |
| | | | | | | | | | 5—6/10 | **6** | 9·0 | 200 | | 10·5 | 21 | | | |
| | | | | | | | | | 4—4/12 | **4** | 6·0 | 250 | | 7·5 | 15 | | | |
| $\frac{3}{4}$ | 0·53 | 14·8 | 3·7 | **3·71** | 12·0 | 3·0 | **2·96** | $\frac{3}{4}$ & over | 7—8/7 | **8** | 18·0 | 160 | 2·13 | 20 | 40 | | | |
| | | | | | | | | | 6—6/9 | **6** | 12·0 | 200 | | 14 | 28 | | | |
| | | | | | | | | | 6—4/13 | **4** | 8·3 | 250 | | 10 | 20 | | | |
| | | | | | | | | | | | * | | * | | * | | | |

NOTES. 1. *The strengths shown are for welds without eccentricity of loading. When designing lap welds, the eccentricity must be allowed for.*

2. *The working stress figures given are based on test results using 28-32 ton structural grade mild steel. If different quality steel is used, the working stresses must be adjusted accordingly.*

3. *All butt welds shown result in reinforcement to the extent of 10% of the area of section. If ground flush, deduct 10% from the working stress.*

4. *If single vee butt welds in plate over ¼" thick are not finished with a run on the back, deduct 50% from the working stress*

5. *The fillet sizes are obtainable from the lengths of run per electrode only when the preparation of work is accurate, the fillet sizes are uniform, and 16¾" of each electrode is deposited. For other conditions suitable allowances must be made.*

6. *The welds marked ❖ are not permissible under the S.A.A. code.*

7. *For costing, see columns marked *, electrode, power and labour. The figures for labour are only intended as a guide, the actual time being entirely dependent on the nature of the work. For vertical welding add 10% and for overhead add 15% to the amount of electrode used, and the cost per lineal foot.*

## MEMORANDUM.